

# Advanced Firefighting Ensemble

*Firefighting Ensemble with Micro-encapsulated Phase Change Material*  
Air Force Research Laboratory (AFRL/MLQC), Tyndall AFB, Florida

## THE NEED

Current thermal barriers used in personal protective equipment (PPE) provide heat and flashover insulation vastly superior to materials of only a few years ago. Unfortunately, they also retain or do not well dissipate the metabolic heat and perspiration generated by the firefighter. In addition, their insulation value declines precipitously when compressed, such as when the firefighter kneels on a hot surface.

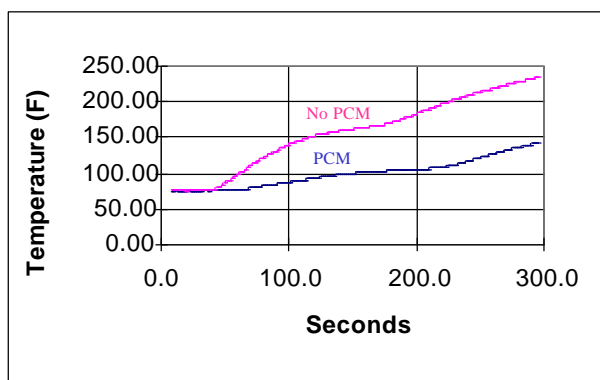
Despite recent technology advances in a wide array of firefighting equipment, communications, and procedures, the accident rate involving burns and heat stress among firefighters has not significantly declined. There is a strong need for improved lightweight PPE thermal liners to pass body heat and moisture to the environment and while remaining effective when compressed.

## THE APPROACH

Materials that absorb and reject large amounts of heat are referred to as phase change materials (PCM). Water is a common example. When cooled to 0°C, it must reject heat to change phase to ice at 0°C. When warmed, ice must absorb heat before it changes phase to water at 0°C. The temperature at which the heat absorption and rejection takes place is known as the phase change temperature.

In conjunction with private industry, the Fire Research Group of the Air Force Research Laboratory (AFRL/MLQC) is incorporating PCMs into PPE thermal liners. Selected paraffins that change phase at temperatures slightly above body temperature are used. Large amounts of heat can be absorbed before an accompanying increase in temperature.

Temperature Next to Skin



The paraffins are encapsulated in a thin-walled, yet very strong substance that results in tough, micro-encapsulated PCM (MPCM). The encapsulation material can withstand substantial compressive forces without rupture or insulative loss. Ranging in size from 10 to 50 microns, the MPCM is set in a breathable foam matrix to form the thermal liner for PPE. MPCM in foam matrices is currently used in a variety of

sporting goods including snow boots, gloves, vests, and bicycle helmets. Depending on the experimental setup and heat or cold intensity, these commercially available textile foams have doubled or tripled exposure time when compared to ordinary thermal barriers.



## THE CHALLENGE

While acceptable for sporting goods, current MPCM-based thermal barriers are not acceptable for PPE. Various Federal and National Fire Protection Association codes must be met and preferably exceeded. When subjected to flame and high radiant or conductive heat they must not burn, drip, or char. They must also provide a minimum of 35 seconds protection from second-degree burn when exposed to a heat flux of 2 cal/cm<sup>2</sup>sec.

## CURRENT STATUS

The search by AFRL/MLQC for a high specific heat capacity fire-resistant PCM which changes phase between 39 to 44°C met with little success. Recent efforts focused on inerting high latent heat organic compounds (e.g., paraffins). Halogenation of the paraffins with bromine, chlorine, or phosphorus shows promise of yielding a flame-resistant PCM with acceptable latent heat. Likewise, candidate foams which are inherently flame resistant, non-toxic when exposed to heat or flame, and breathable are undergoing selection. An open cell silicone based foam shows promise of meeting the criteria.

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